US010007592B2

(12) United States Patent
Bagchi et al.

(10) **Patent No.:** **US 10,007,592 B2**
(45) **Date of Patent:** **Jun. 26, 2018**

(54) **DEBUGGING NON-DETERMINISTIC EMBEDDED SYSTEMS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 16 days.

(21) Appl. No.: **15/031,230**

(22) PCT Filed: **Oct. 3, 2014**

(86) PCT No.: **PCT/US2014/058999**
§ 371 (c)(1),
(2) Date: **Apr. 21, 2016**

(87) PCT Pub. No.: **WO2015/061022**
PCT Pub. Date: **Apr. 30, 2015**

(65) **Prior Publication Data**

US 2016/0314055 A1   Oct. 27, 2016

Related U.S. Application Data

(60) Provisional application No. 61/893,923, filed on Oct. 22, 2013.

(51) **Int. Cl.**
G06F 11/00 (2006.01)
G06F 11/36 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **G06F 11/366** (2013.01); **G06F 9/30098** (2013.01); **G06F 9/3865** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 11/366; G06F 11/362; G06F 11/364; G06F 11/3612; G06F 11/3636;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,043,668 B1	5/2006	Treue et al.	
7,178,133 B1	2/2007	Thekkath	

(Continued)

FOREIGN PATENT DOCUMENTS

WO   WO2010/002489   1/2010

OTHER PUBLICATIONS

Choudhuri, S. et al., "FlashBox: A System for Logging Non-Deterministic Events in Deployed Embedded Systems", SAC, Mar. 8-12, 2009, 7 pages.

(Continued)

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(57) **ABSTRACT**

An embedded device includes a processor executing instructions from module(s) in a code memory. The instructions specify: reading data from two non-deterministic registers (NDRs) of different types, compressing the data using respective, different compression algorithms, and storing the compressed data in a nonvolatile medium. A method of enabling debug tracing in a computer program product (CPP) includes locating instructions in the CPP that read NDRs, determining types of the NDRs, and adding instruction(s) to the CPP to compress the values read using compression algorithms corresponding to the respective NDR

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